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ORIENTATION-ERROR ACCIDENTS IN REGULAR ARMY UH-1 AIRCRAFT DURING FISCAL YEAR 1967: RELATIVE INCIDENCE AND COST

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SUMMARY PAGE

THE PROBLEM

From the military mission viewpoint, the amount of research effort to be expended on the solution of a given aviation medicine problem must be keyed to the operational cost of the problem. Therefore, a necessary first step in the development of a solution is the assimilation of data that define the magnitude of the problem. Though orientation-error accidents involving pilot disorientation and vertigo have been long recognized to exist, little quantitative data are available to describe the actual incidence and cost of such accidents in Army aviation.

FINDINGS

To initiate the action necessary to establish the magnitude of the orientation-error problem in Army aviation, an interservice research program was organized under the joint sponsorship of the U. S. Army Aeromedical Research Laboratory, the U. S. Army Board for Aviation Accident Research, and the Naval Aerospace Medical Research Laboratory. The first task was the construction of an operational definition of an orientation-error accident. The assimilation of data pertaining to the incidence and cause of such accidents and their actual and relative costs in terms of fatalities, injuries, and aircraft damage was then set as the working objective of the program. Accordingly, the decision was made to implement a five-year longitudinal study of all major and minor orientation-error accidents involving Regular Army flight operations beginning with fiscal year 1967. Findings will be summarized on a fiscal-year busis in three separate lines of reports: The first line will be devoted to defining the over-all magnitude of the orientation-error problem in all aircraft types; the second line to the presentation of similar incidence and cost data for accidents involving only the UH-1 aircraft, the predominant rotary wing aircraft in the Army inventory; and the third line to the description of the various causal factors found to be present in the major UH-1 orientation-error accidents.

This specific report is the first in the series dealing with the magnitude of the orientation-error problem in UH-1 aircraft. Incidence and cost data are presented for all major and minor orientation-error accidents involving Regular Army UH-1 flight operations that were detected in the search of the fiscal year 1967 accident files.

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The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

ACKNOWLEDGMENTS

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LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

In 1968, the authors organized an interservice research program under the joint sponsorship of the U. S. Army Aeromedical Research Laboratory (USAARL), the U. S. Army Board for Aviation Accident Research (USABAAR), and the Naval Aerospace Medical Research Laboratory (NAMRL) to investigate the operational role of pilot disorientation and vertigo in the production of orientation-error type aircraft accidents. Since little quantified data were available to describe the actual magnitude of the orientation-error problem in Regular Army flight operations, the decision was made to conduct a five-year longitudinal study, beginning with fiscal year 1967, of all Army aircraft accidents that involved an erroneous judgment of aircraft motion or attitude on the part of the pilot. Two separate, but related, project objectives were set for the longitudinal study. The first was to extract and assimilate data from the USABAAR master aircraft-accident files which would define the actual and relative cost of orientation-error accidents to Regular Army flight operations. These data, by defining the operational magnitude of the problem,would then serve to define the extent of the research support which should be devoted to its solution. The second working objective was to extract data on a case-history basis which would describe the various pilot/aircraft/mission/environment factors found to be present in each of the orientation-error accidents. Assimilation and analysis of these data over the study period would result in better knowledge of the most common operational causes of orientation-error accidents and thus point out those research directions which offer the greatest potential toward the reduction of accident incidence.

The results of the longitudinal study will be summarized in three separate lines of reports, with one report in each line prepared for each fiscal year of the five-year study. The first line of reports (for example, ref. 1) will be devoted to defining the magnitude of the orientation-error accident problem in all aircraft types. The incidence and cost of all major and minor orientation-error accidents involving all aircraft types, fixed wing as well as rotary wing, that occurred in Regular Army flight operations will be reported for each fiscal year. Since the UH-1 "Huey" helicopter has been, and is, the predominant aircraft in the Army rotary wing inventory, in fact the predominant aircraft in the combined fixed wing and rotary wing inventory, the second line of reports will be devoted to defining the magnitude of the orientation-error accident problem in only this aircraft. The layout and format of this line of reports will be almost identical to that of the first line. The third line of reports (for example, ref. 2) will deal exclusively with the various causal factors found to be present in all of the major UH-1 orientation-error accidents. Typical data to be presented include phase of flight, time of day, type of mission, pilot experience, physiological factors, psychological factors, facility factors, environmental factors, and the like.

This specific report is the first of the second line of reports and describes the incidence and cost of all Regular Army UH-1 orientation-error accidents detected in the search of the USABAAR fiscal year 1967 files. In addition, corresponding cost data are presented both for all accident types, regardless of cause, and for pilot-error accident types so as to establish the relative magnitude of the UH-1 orientation-error accident problem. The graphical layout of this report follows that developed for the first line of

reports (1) where emphasis is placed on a format that will facilitate direct comparison of data collected in one fiscal year with those collected for other years.

PROCEDURE

The procedure used to extract the accident data from the USABAAR files has been described previously (1). However, since proper interpretation of the data depends upon a thorough understanding of what has been defined as an orientation-error accident, the procedure is repeated for reader convenience.

To initiate the program it was necessary first to establish a workable definition of the class of accidents to be identified as orientation-error accidents. It will be recognized by investigators actively engaged in aviation safety research that the cliché "easier said than done" is most appropriate for this task. There would be little difficulty in identifying accidents involving pilot disorientation if the latter always manifested itself in the extreme where a pilot calls out that he is experiencing severe vertigo and is having difficulty controlling his aircraft. Similarly, when visibility is poor or the visual environment conducive to illusions, the task of identifying an accident as being related to difficulty in maintaining spatial orientation is not too difficult. However, when the factors surrounding a given accident become borderline as to whether or not a pilot made an orientation error, it is of the essence that the accident classifier be given some appropriate criteria to help him make the classification decision. Although any definition of orientation error will be compromised at times by one or more unique features of a given accident, it was felt that a workable classifying system could be developed for the vast majority of the accident types to be encountered in our review.

DEFINITION OF ORIENTATION-ERROR ACCIDENTS

First, the term orientation is considered to involve the correct determination of the dynamic position and attitude of an aircraft in three-dimensional space. The key word here is dynamic, which implies that full knowledge of the motion as well as the static attitude or position of an aircraft is required to define its instantaneous spatial orientation. For a pilot to have a full comprehension of his orientation, it is essential, for example, that he be able to describe the static pitch and roll attitude of his aircraft relative to some external reference such as the Earth-vertical defined by the gratitational vector; his yaw attitude relative to some geographical heading; the linear velocity of the aircraft, with or without attendant linear acceleration, in terms of fore-aft, left-right, and up-down motions; and the angular velocity of the aircraft, with or without attendant angular acceleration, in terms of roll, pitch, and yaw rotary motions of the aircraft. Thus, for a fully oriented fixed-wing aircraft pilot, typical information inputs would include knowledge of the forward speed of the aircraft, the vertical speed in terms of either climb or descent rates, sideward drift velocity, pitch and roll attitude, as well as bank angles, angle of attack, et cetera. In landing or rendezvous operations, recognition of the effects of these aircraftmotions on absolute distance must be made to ensure that the aircraft does not undershoot or overshoot a preselected touchdown or rendezvous point.

The rotary-wing aircraft pilot requires similar information. However, during low-level hovering conditions, additional information is required in the form of linear velocity in the backward as well as forward direction. Unfortunately, the majority of the currently operational helicopters do not have instruments that provide this backward velocity or, for that matter, sideward drift velocity information. The usual lack of short-range radar altimeters in helicopters is another problem confronting the rotary-wing aircraft pilot during low-level operations performed with poor ground visibility.

By this definition of the word orientation, it follows that a pilot will be considered to have made an orientation error whenever his perception of the motion and attitude of his aircraft differs from the true motion and attitude; i.e., the true orientation of the aircraft. The exact magnitude of an orientation error will obviously vary over a wide range. In the case where a pilot suffers severe vertigo and completely loses all perception of either aircraft motion or aircraft attitude, the probability of a large-scale orientation error is high, as is the probability of an accident if the disorientation is prolonged or is experienced at a critical control phase within the flight. In another case, the pilot may sense or feel that the aircraft is climbing or turning when in actuality it may be flying straight and level. If during this disorientation experience the pilot accepts that his sensations define the orientation of the aircraft, then an orientation error is present. However, if he realizes that his sensations are in conflict with another input, say the aircraft instruments, and intellectually arrives at the correct judgment of the true motion and attitude, then though the pilot is experiencing disorientation, an orientation error does not result.

Initially, then, an orientation error accident can be defined as one that occurs as a result of an incorrect control or power action taken by a pilot due to his incorrect perception of the true motion and attitude of his aircraft. Using this definition, an accident classifier can place primary emphasis on determining whether or not the accident involved an erroneous judgment of orientation on the part of the pilot. It follows that questions pertaining to the causes of the orientation error, or its manifestation to the pilot, need not be immediately answered during the initial classification.

There must, however, be several qualifications to this definition. For instance, the accident situation must be one in which the demands on pilot skill are reasonable. To illustrate, consider a helicopter pilot who has a main rotor strike as a result of landing from a hover in a nonlevel attitude, say with an excessive roll angle. This is an orientation-error accident involving incorrect perception of aircraft attitude. The causes of the orientation error could be much varied, ranging from inattention to instruments, a tilted horizon, visual illusions produced by nearby moving aircraft, or distraction. A simple but essential assumption is that the pilot did not deliberately fly his aircraft into the ground. However, if in a similar landing from a hover situation, a nearby helicopter flies over the given aircraft and produces severe rotor downwash or turbulence, and the end result is a similar rotor strike, the accident would not be classified as an orientation-error accident. It is not reasonable to expect the pilot to maintain both perception and control of aircraft orientation under these conditions. In like manner, a tail rotor strike resulting from excessive flare applied by the pilot in a landing formation to avoid striking

another aircraft making an unauthorized takeoff would not be classified as an orientation-error accident. But again, if this tail rotor strike occurred during a routine uninterrupted landing, it would fall into our classification since the pilot's perception of closing rate or pitch angle was incorrect.

A further qualification involves accidents associated with navigation errors. Though knowledge of heading is pertinent to orientation, accidents involving navigation mistakes, and only navigation mistakes, are not classified as orientation-error accidents. That is, if a pilot strikes a hillside as a result of flying a course of 100 degrees instead of 200 degrees, the error is one of navigation, not orientation. In this respect, the word misorientation has received some usage to account for navigation errors. However, if in addition to being on the wrong course or heading, a pilot is having difficulty controlling his aircraft and an accident results because of this difficulty, an orientation-error accident classification would generally result.

Accidents resulting from collision with unseen objects, e.g., a wire strike, are also not included if the collision occurs during normal controlled flight. However, if a hovering pilot allows his aircraft to drift backward, without detection, and finally to impact against an unseen object, an orientation-error classification would result. That is, collisions of this sort are included only when they derive from an orientation error.

As qualified by all of the above, an orientation-error accident is thus said to occur whenever an accident results from a pilot's incorrect perception of his true motion and attitude in space. The orientation error may range from a complete loss of all knowledge of orientation to simple confusion as to only one of the many motion and attitude parameters required to be recognized by the pilot. Or, as mentioned previously, the pilot may never realize that the motion or attitude of his aircraft is gradually changing so as to be soon unfavorable to safe flight.

ACCIDENT-FILE SEARCH PROCEDURES

With this definition of orientation-error accidents serving as a classification reference, a comprehensive search was made of the USABAAR accident files to determine all major and minor accidents (as defined in refs. 3, 4) that occurred in Regular Army flight operations during fiscal year 1967. This search involved having a classifier, with previous experience in detecting disorientation/vertigo accidents, read each and every accident brief in the master files. These briefs covered all types of accidents in all types of aircraft, fixed wing and rotary wing, and included noncombat accidents occurring in Viet Nam as well as those occurring in all other Army operations.

For redundancy, the entire accident file was also searched by means of coded summaries that USABAAR prepares for each accident. These summaries, in punched card form, list the essential background data of a given accident as well as the primary causal factors. These cards were searched with the objective of obtaining the accident identification number of all accidents involving vertigo, disorientation, poor visibility, bad weather, obstructed vision, night flight difficulties, visual illusions, and the like.

RESULTS AND DISCUSSION

To place the operational significance of UH-1 orientation-error accidents in proper perspective, it is necessary to have at least a cursory understanding of the incidence and cost of UH-1 aircraft accidents in general. As with the first report (1) of the all-aircraft series, this is accomplished as follows: The lead section below is devoted to describing the over-all cost of all Regular Army UH-1 aircraft accidents, regardless of type or location, that occurred during fiscal year 1967. In a second section, equivalent data in a nearly identical format are presented to separately identify those UH-1 accidents in the first section that were classified by USABAAR as involving one or more pilot-error factors. Incidence and cost statistics pertaining only to UH-1 orientation-error accidents are then presented in a third section. By using these three sets of data as independent references, it then becomes possible to derive some quantitative insight into the relative, as well as actual, cost of UH-1 orientation-error accidents in Regular Army flight operations. Selected comparative relationships are presented in the last section of the report.

ALL TYPES OF UH-1 AIRCRAFT ACCIDENTS

The data presented in this section describe the incidence and cost of all major and minor UH-1 helicopter accidents involving Regular Army flight operations during fiscal year 1967. Separate data groupings are provided for those accidents that occurred in Viet Nam, those accidents that occurred elsewhere, and their combined total. Since the vast majority of the accidents that do not occur in Viet Nam (VN) take place within the continental limits of the United States, the abbreviation US is arbitrarily used to denote all accidents that do not occur in Viet Nam. It should be realized then that the US data grouping will include a small number of accidents that may have occurred, for example, in Europe, Africa, or elsewhere. A second point to be stressed is that the VN data pertain strictly to accidents, not losses due to enemy action.

In the interpretation of the accident statistics to follow, it becomes possible to compare VN and US accident incidence only when some common measures of aircraft utilization are selected as weighting factors. A similar requirement exists for comparison of accident incidence in one given fiscal year with incidence in other fiscal years. To establish such references, percent aircraft inventory, total flying hours, and total aircraft landings are used as basic weighting data in this report. These data, as well as the incidence and cost statistics discussed in this section, are summarized in Table I.

The aircraft inventory data of Table I show that for fiscal year 1967, the average number of UH-1 aircraft operating out of Viet Nam was 51.81 percent of the total Regular Army UH-1 aircraft inventory. As illustrated by the VN/US aircraft inventory ratio of 1.08 to 1, aircraft utilization as measured by inventory was about the same in Viet Nam as it was elsewhere. This is in contradistinction to the previously presented (1) VN/US aircraft inventory ratio of 0.66 to 1 for all types of rotary wing aircraft including the UH-1. These data indicate that the percentage of the total UH-1 inventory stationed in Viet Nam was higher than the percentage of the total inventory of all other types of rotary wing aircraft stationed in Viet Nam.

TABLE I

FISCAL YEAR 1967 DATA

ALL ACCIDENT TYPES — UH-1 AIRCRAFT ONLY

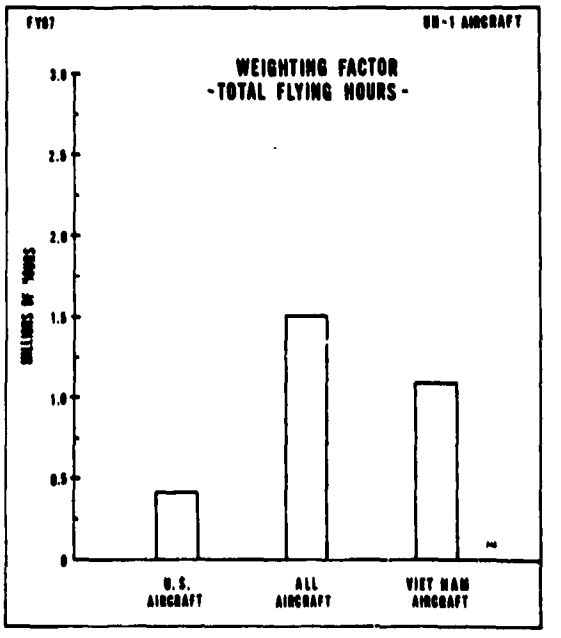
ACCIDENT INDEX	U.S. ACCIDENTS	VIET NAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	50	361	411	7.22
Minor Accidents	13	31	44	2.38
Total Accidents	63	392	455	6.22
Aircraft Inventory - Per Cent Total	48.19	51.81	100.00	1.08
Total Flying Hours	421,097	1,084,731	1,505,828	2.58
Total Landings	1,773,350	3,294,829	5,068,179	1.86
Major Accidents per 100,000 Hours	11.87	33.28	27.29	2.80
Minor Accidents per 100,000 Hours	3.09	2.86	2.92	0.93
Total Accidents per 100,000 Hours	14.96	36.14	30.22	2.42
Major Accidents per 100,000 Landings	2.82	10.96	8.11	3.89
Minor Accidents per 100,000 Landings	0.73	0.94	0.87	1.29
Total Accidents per 100,000 Landings	3.55	11.90	8.98	3.35
Total Dollar Cost	8,185,445	54,458,656	62,644,101	6.65
Average Dollar Cost per Accident	129,928	138,925	137,679	1.07
Total Fatalities	32	228	260	7.13
Average Fatalities per Accident	0.51	0.58	0.57	1.14
Fatal Accidents - Number	10	75	85	7.50
Fatal Accidents - Percent	15.87	19.13	18.68	1.21
Average Fatalities per Fatal Accident	3.20	3.04	3.06	0.95
Total Injuries (Nonfatal)	59	474	533	8.03
Average Injuries per Accident	0.94	1.21	1.17	1.28

In terms of total flying hours of UH-1 aircraft, however, aircraft utilization was considerably greater in VN than elsewhere, as shown in Figure 1A. The right-hand bar of this figure represents the total number of flight hours logged by UH-1 aircraft operating out of Viet Nam. The left-hand bar denotes total UH-1 flying hours logged elsewhere, primarily in the United States. The central bar is the direct sum of the adjacent data to either side and represents the total number of flight hours logged in all UH-1 aircraft for this fiscal year. Thus, the total hours data of Figure 1A and Table I indicate that Regular Army UH-1 aircraft were flown a total of 1,505,828 hours during fiscal year 1967. Of this total, 1,084,731 hours were flown in VN and only 421,097 hours flown elsewhere. The higher utilization in VN results in a VN/US total flying hours ratio of 2.58 to 1. A similar, but smaller, VN predominance results when total landings are used as a weighting reference (Figure 1B). Of the 5,068,179 total UH-1 landings, 3,294,829 occurred in VN and 1,773,350 landings occurred elsewhere, resulting in a VN/US total landings ratio of 1.86 to 1. Again this is in contradistinction to the corresponding data presented for all rotary wing aircraft (1). Here the VN/US total flying hours ratio was 0.89 to 1 and the VN/US total landings ratio was 0.64 to 1 for the same period.

With these aircraft utilization data serving as background reference, it becomes possible to make a weighted interpretation of the raw accident data presented in Table I. Selected excerpts from these data are presented in Figures 2 and 3. The numerical incidence of all major and minor UH-1 aircraft accidents, regardless of type or causal factor, is plotted in Figure 2. The cost of these accidents, as measured by the number of fatal accidents, number of fatalities, number of nonfatal injuries, and aircraft dollar damage is outlined in Figures 3A through 3D, respectively.

In terms of the over-all UH-1 accident problem, these data show that during fiscal year 1967, there were a total of 455 accidents (85 of which were fatal), resulting in 260 fatalities, 533 nonfatal injuries, and a UH-1 aircraft damage cost of $62,644,101. The Viet Nam contribution to this total was 392 accidents (75 of which were fatal), resulting in 228 fatalities, 474 nonfatal injuries, and an aircraft damage cost of $54,458,656. In all cases, the unweighted incidence and cost of accidents occurring in VN exceeded those of accidents occurring elsewhere. That is, the VN/US total accident ratio was 6.22 to 1, the VN/US total fatal accident ratio was 7.50 to 1, the VN/US total fatality ratio was 7.13 to 1, the VN/US total nonfatal injury ratio was 8.03 to 1, and the VN/US aircraft damage cost ratio was 6.65 to 1.

To facilitate the comparison of these fiscal year 1967 accident incidence data to accident incidence in other fiscal years covered by the longitudinal study, the data in Figure 2 have been normalized relative to the total number of flying hours flown in each location and plotted in Figure 4A as the average number of accidents occurring every 100,000 hours. The same normalization using total landings as reference was accomplished for Figure 4B, which shows the accident rate for every 100,000 landings. With the total number of UH-1 accidents as reference, these data show that, on the average, there were 30.22 accidents per 100,000 hours and 8.98 accidents per 100,000 landings. When compared to the corresponding data (1) for all rotary wing aircraft, i.e., 23.46 accidents per



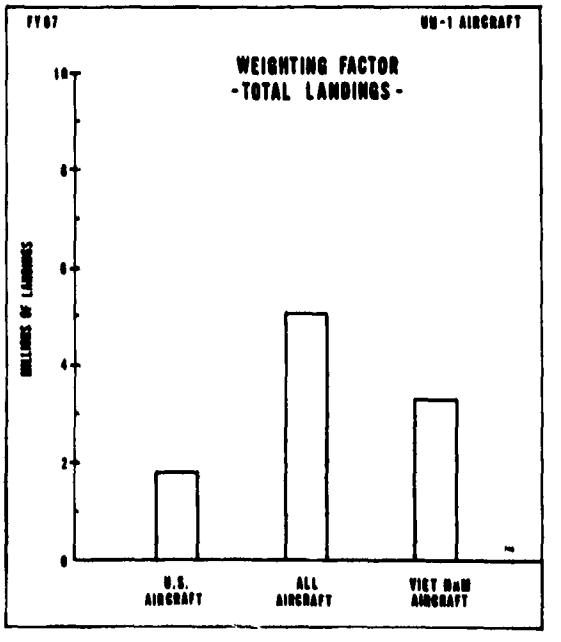


Figure 1

Total flying hours (A) and total landings (B) by location of UH-1 (Huey) helicopter aircraft flown in Regular Army flight operations during fiscal year 1967. In 1A, the right-hand bar indicates total hours flown in Viet Nam, the left-hand bar total hours flown elsewhere (primarily in the United States), and the central bar the direct sum of the adjacent data to either side. The format of the total landing data in 1B follows identically. Note that utilization of the UH-1 aircraft in terms of both hours and landings was greater in Viet Nam.

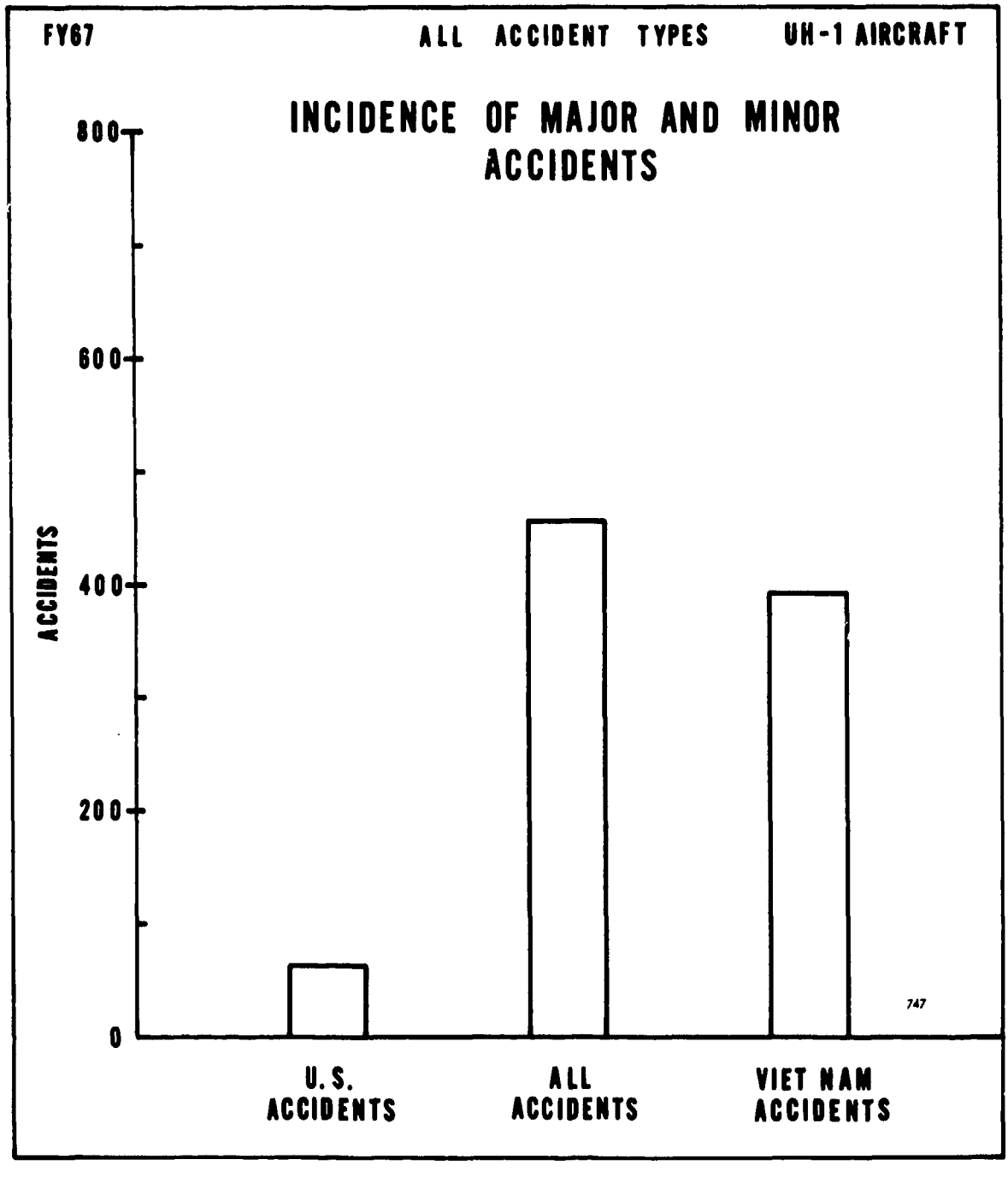
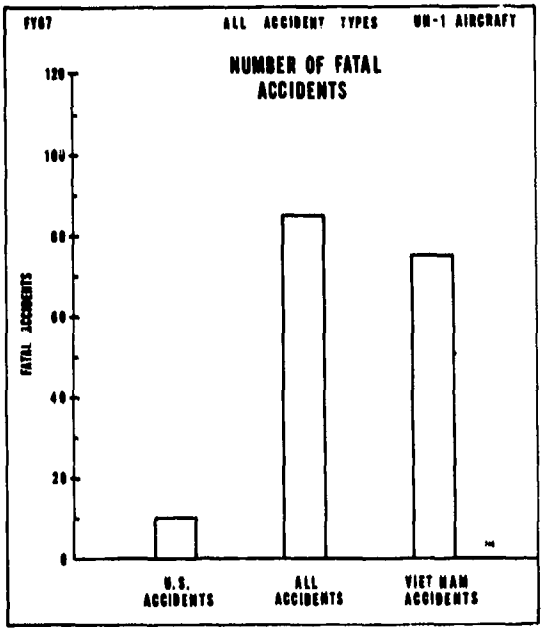
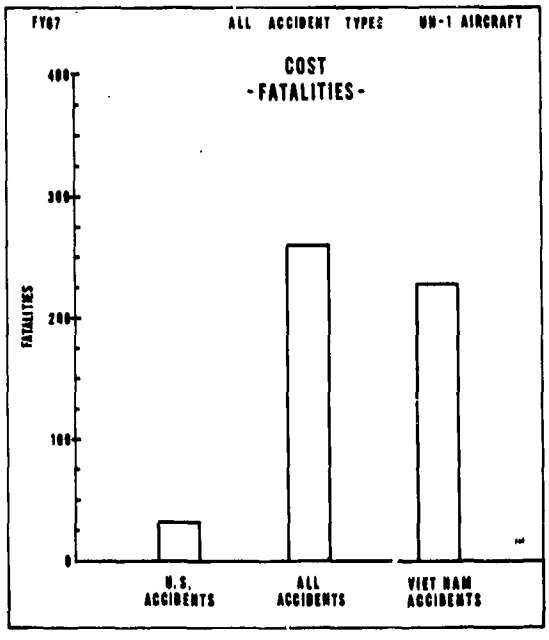
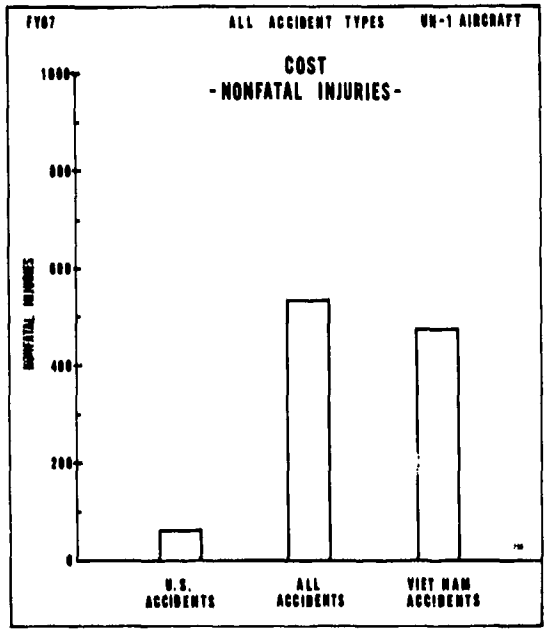


Figure 2

All UH-1 Accident Types: Total number of major and minor UH-1 aircraft accidents of all types that occurred in Regular Army flight operations during fiscal year 1967. The right-hand bar denotes the number of UH-1 accidents that occurred in Viet Nam, while the left-hand bar denotes the number of accidents that occurred elsewhere. This latter bar has been identified as "U. S. Accidents" for convenience since the vast majority of the accidents that do not occur in Viet Nam (VN) take place within the continental limits of the United States (US). This convention applies throughout the remaining report figures. The central bar totalizes the adjacent VN and US data. As described in the text, the VN data pertain to accidents, not losses due to enemy action.







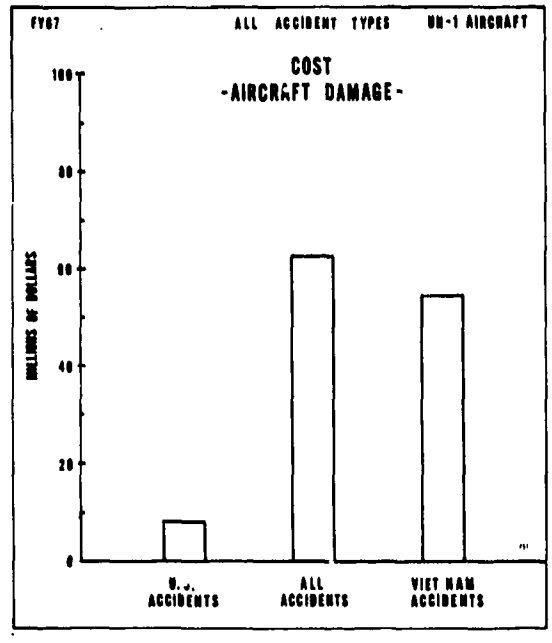
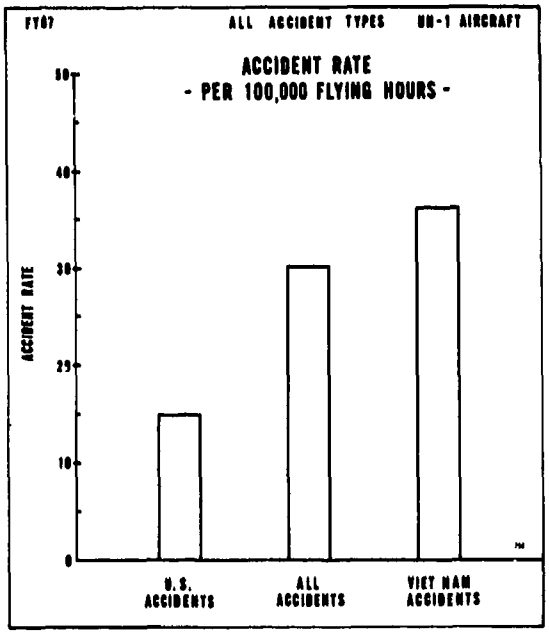


Figure 3

All UH-1 Accident Types: Total number of fatal accidents (A), total number of fatalities (B), total number of nonfatal injuries (C), and total dollar cost of resulting UH-1 aircraft damage (D).



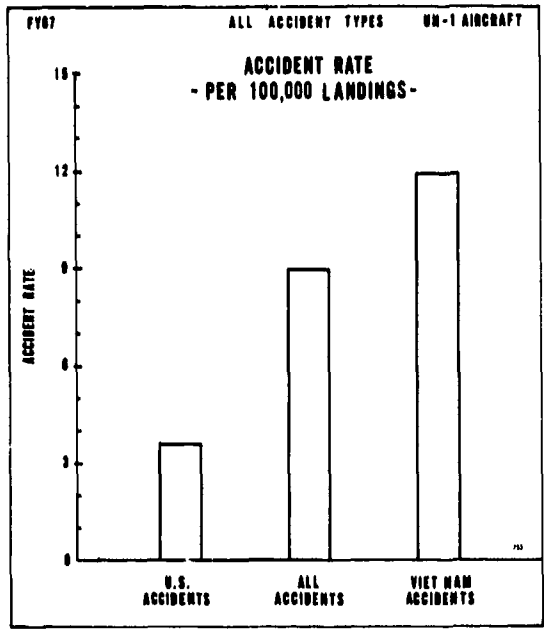


Figure 4

All UH-1 Accident Types: Normalized incidence data showing the average number of UH-1 accidents per 100,000 flying hours (A) and average number of accidents per 100,000 landings (B). The VN accident rate was 2.42 times greater than the US rate when total hours were used as reference and 3.35 times greater when total landings served as reference.

100,00 hours and 6.45 accidents per 100,000 landings, it can be seen that the UH-1 accident rates were greater. The UH-1 data also indicate that, even after normalization, the accident rate in VN was greater than that elsewhere. That is, the accident rate in VN was 2.42 times greater than the rate elsewhere, using total hours as reference, and 3.35 times greater, using total landings as reference. However, when compared to the corresponding data (1) for all rotary wing aircraft, i.e., a VN accident rate 3.11 times greater than that elsewhere based on hours and a VN rate 4.35 times greater based on landings, it can be seen that the ratios for the UH-1 were slightly smaller for this same period.

UH-1 PILOT-ERROR ACCIDENTS

In this section, incidence and cost data are presented for all UH-1 accidents that were classified by USABAAR as involving one or more pilot-error causal factors. It should be observed that this classification does not imply that pilot error was the only, or even the primary, accident causal factor. That is, this grouping includes all UH-1 accidents involving one or more pilot errors even though, for example, materiel failure, maintenance shortcomings, or poor facilities may also have contributed to the accident. A further point,by definition, is that these pilot-error accidents are a subgroup of the all-accident statistics discussed in the previous section.

Incidence and cost data for these fiscal year 1967 pilot-error accidents are presented in Table II and Figures 5 and 6 (A-D). These data show that there were a total of 309

TABLE II
FISCAL YEAR 1967 DATA

PILOT-ERROR ACCIDENTS ONLY — UH-1 AIRCRAFT

ACCIDENT INDEX	U.S. ACCIDENTS	VIET NAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	38	243	281	6.39
Minor Accidents	10	18	28	1.80
Total Accidents	48	261	309	5.44
Total Dollar Cost	5,848,928	34,654,756	40,503,684	5.92
Average Dollar Cost per Accident	121,853	132,777	131,080	1.09
Total Fatalities	10	127	137	12.70
Average Fatalities per Accident	0.21	0.49	0.44	2.81
Fatal Accidents - Number	5	47	52	9.40
Fatal Accidents - Percent	10.42	18.00	16.83	1.73
Average Fatalities per Fatal Accident	2.00	2.70	2.63	1.35
Total Injuries (Nonfatal)	50	316	366	6.32
Average Injuries per Accident	1.04	1.21	1.18	1.16

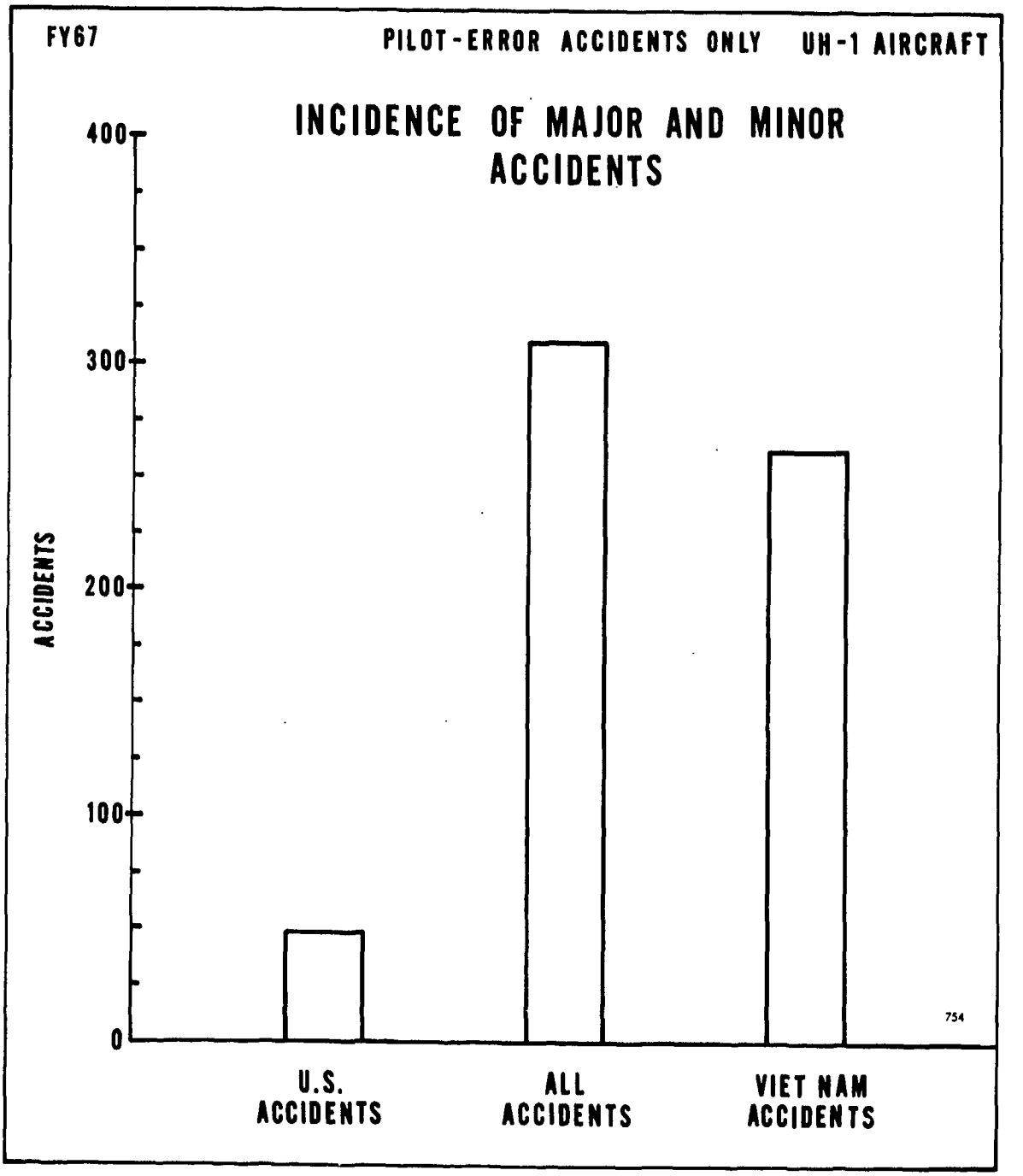
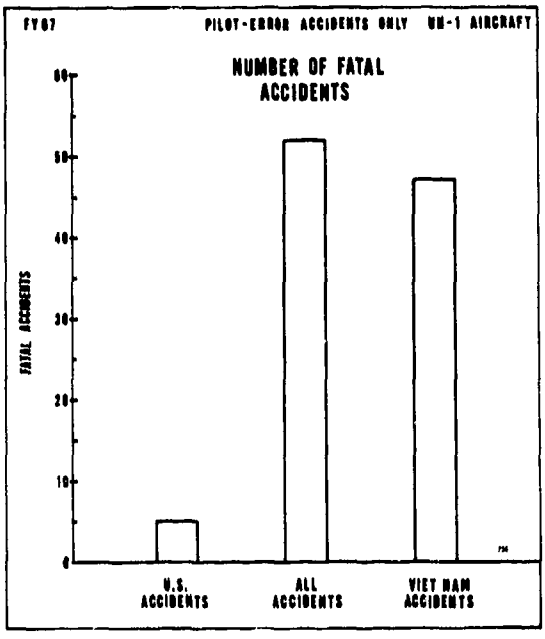
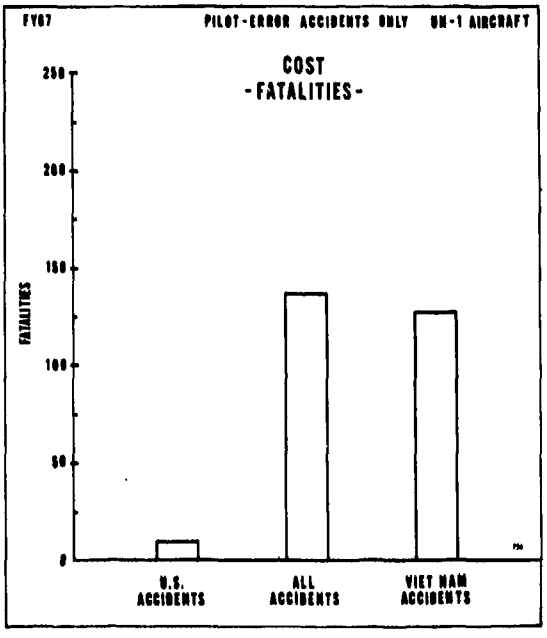
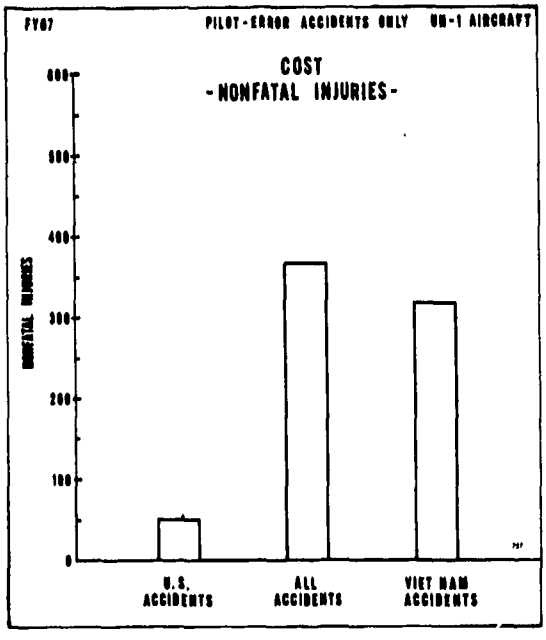


Figure 5

UH-1 Pilot-Error Accident Types: Total number of major and minor UH-1 aircraft accidents involving the presence of one or more pilot-error factors as classified by USABAAR.







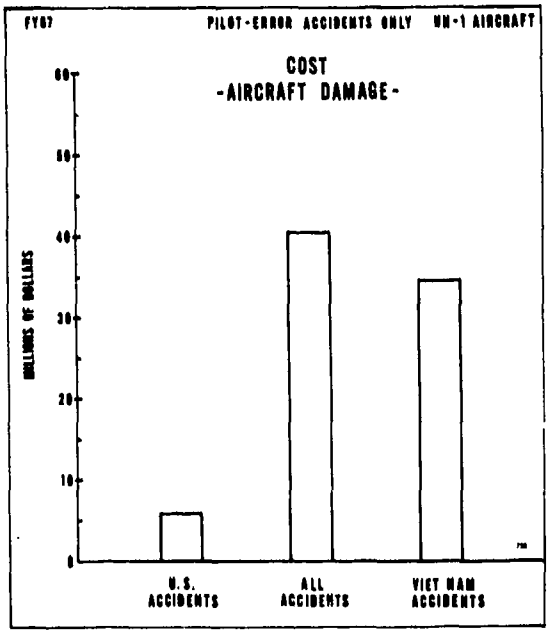
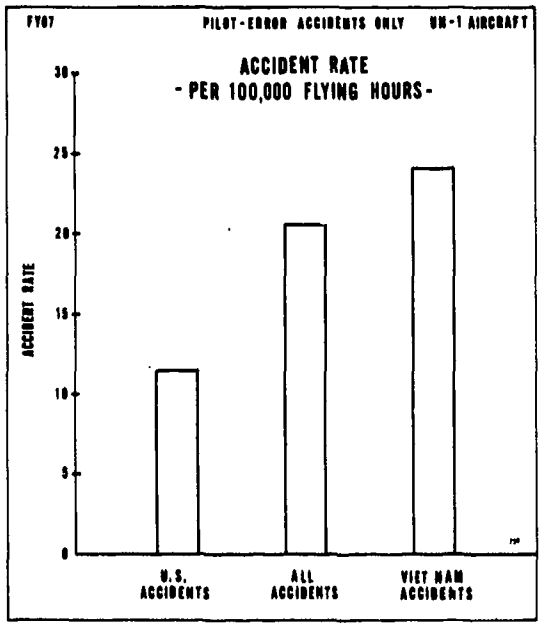


Figure 6

UH-1 Pilot-Error Accident Types: Total number of fatal accidents (A), total number of fatalities (B), total number of nonfatal injuries (C), and total dollar cost of resulting UH-1 aircraft damage (D).



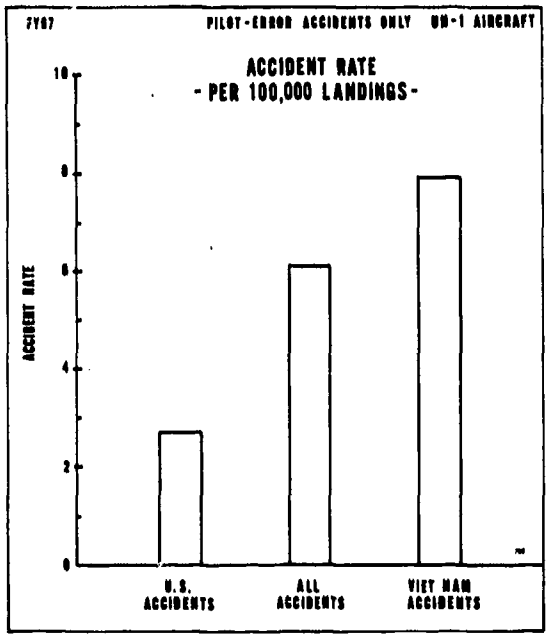


Figure 7

UH-1 Pilot-Error Accident Types: Normalized incidence data showing the average number of UH-1 pilot-error accidents per 100,000 flying hours (A) and average number of accidents per 100,000 landings (B). The total hours and total landings data of Figure 1 served as normalization reference. These rate data are intended only as a fiscal year 1967 baseline reference for comparison with similar data for later fiscal years, which will be presented in following reports.

major and minor UH-1 pilot-error accidents (52 of which were fatal), resulting in 137 fatalities, 366 nonfatal injuries, and an aircraft damage cost of $40,503,684. As with the all-accident data, the incidence and cost of pilot-error accidents that occurred in Viet Nam were considerably higher than those which occurred elsewhere. From Table II it can be seen that the VN/US accident incidence ratio was 5.44 to 1, the VN/US fatal accident ratio was 9.40 to 1, the VN/US fatality ratio was 12.70 to 1, the VN/US nonfatal injury ratio was 6.32 to 1, and the VN/US aircraft damage cost ratio was 5.92 to 1.

In Figure 7, the accident incidence data are normalized relative to total hours (A) and total landings (B) of the UH-1 aircraft. As indicated in Figure 7A, the over-all pilot-error accident rate based on the total hours data of Figure 1A was 20.52 accidents per 100,000 hours. In VN and US, the rates were 24.06 and 11.40 accidents, respectively, per 100,000 hours, which results in a VN/US ratio of 2.11 to 1. Figure 7B data show an over-all pilot-error accident rate, based on the total landings data of Figure 1B, of 6.10 accidents per 100,000 landings. In VN and US, the rates were 7.92 and 2.71 accidents, respectively, per 100,000 landings, which results in a VN/US ratio of 2.93 to 1. As with Figure 4, the data of Figure 7 are intended primarily to establish a comparative reference for pilot-error accident rate data to be presented for other fiscal years within the longitudinal study interval.

UH-1 ORIENTATION-ERROR ACCIDENTS

This section summarizes, for fiscal year 1967, the incidence and cost of all UH-1 orientation-error accidents detected in our review of the USABAAR accident files. As detailed with selected qualifications in the procedure section of this report, this listing includes all accidents that were classified as involving incorrect pilot perception of aircraft motion or attitude. The reader should recognize that the orientation-error accidents discussed herein are a subgroup of the pilot-error accident statistics presented in the previous section. The main elements of the UH-1 orientation-error statistics are summarized in Table III. The pertinent incidence and cost data are outlined in Figures 8 and 9 (A-D). Normalized accident rate data for these accidents are presented in Figure 10 (A, B) for comparison of incidence in later fiscal years.

These data show that during fiscal year 1967, there were a total of 50 major and minor UH-1 orientation-error accidents (15 of which were fatal), resulting in 38 fatalities, 88 nonfatal injuries, and an aircraft damage cost of $7,542,177. As with the all-accident and pilot-error accident data, the orientation-error data show a much higher accident incidence in Viet Nam; i.e., the VN/US total accident incidence ratio was 6.14 to 1 for UH-1 orientation-error accidents. For this particular fiscal year, however, a VN/US ratio for either fatal accidents or fatalities cannot be established since no fatal UH-1 orientation-error accidents were found to occur in US, as denoted by the n = 0 entry in Figures 9A and 9B. The VN/US nonfatal injury ratio was 7.00 to 1 and the VN/US aircraft damage ratio was 5.84 to 1.

The accident rate data of Figure 10, derived from the total hours (A) and total landings (B) data of Figure 1, indicate that there was an over-all average of 3.32 and 0.99 orientation-error accidents per 100,000 hours and per 100,000 landings, respectively, for

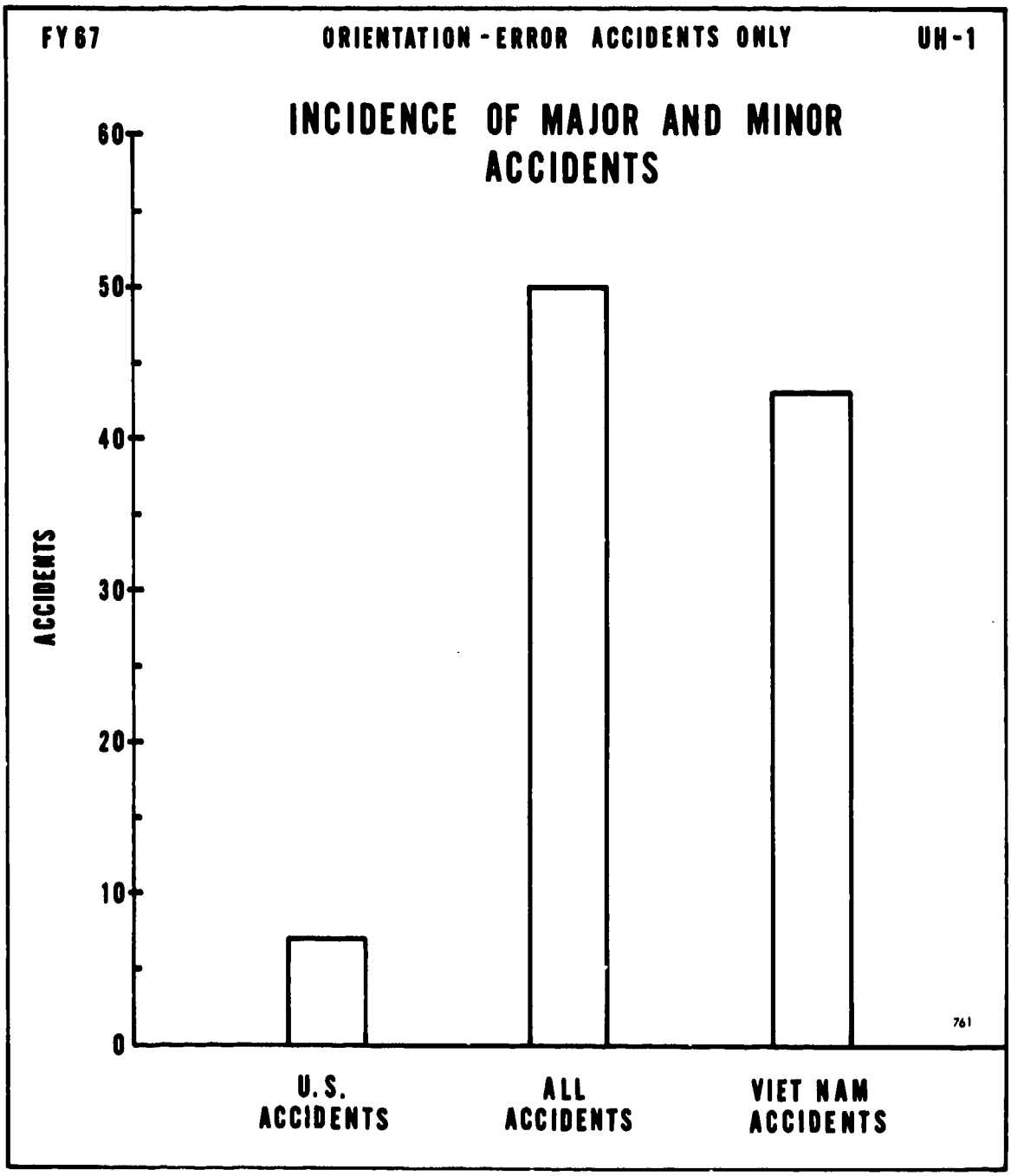
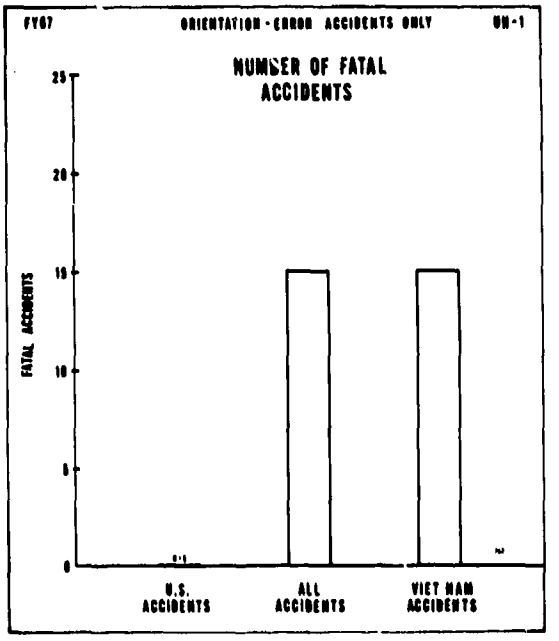
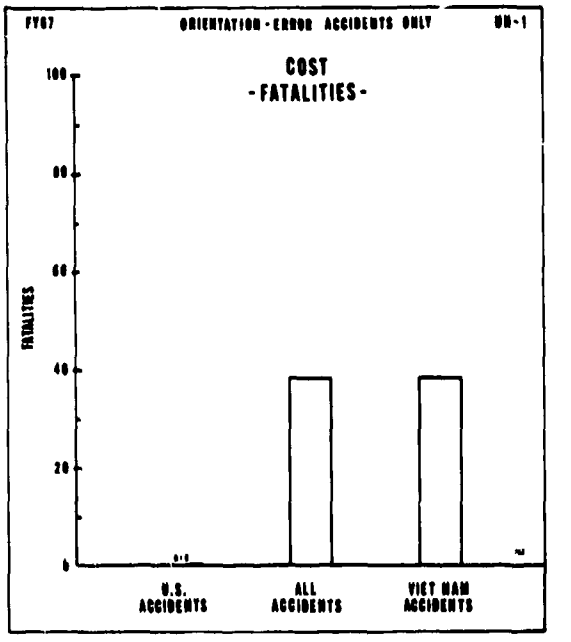
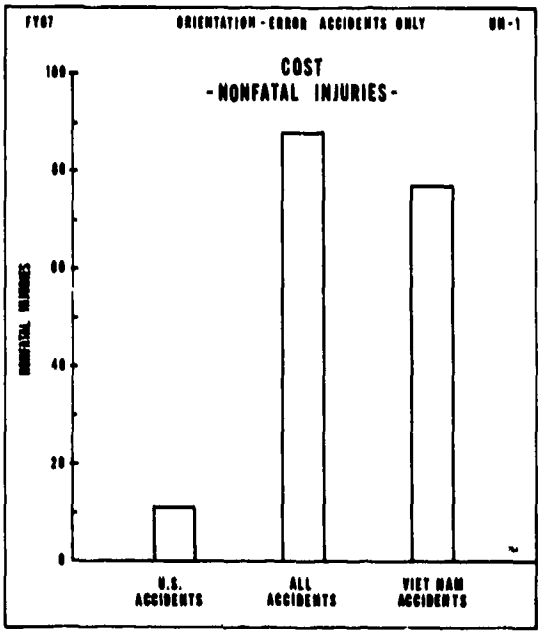


Figure 8

UH-1 Orientation-Error Accident Types: Total number of major and minor UH-1 aircraft accidents involving orientation error which were detected in the search of the USABAAR master accident files for fiscal year 1967.







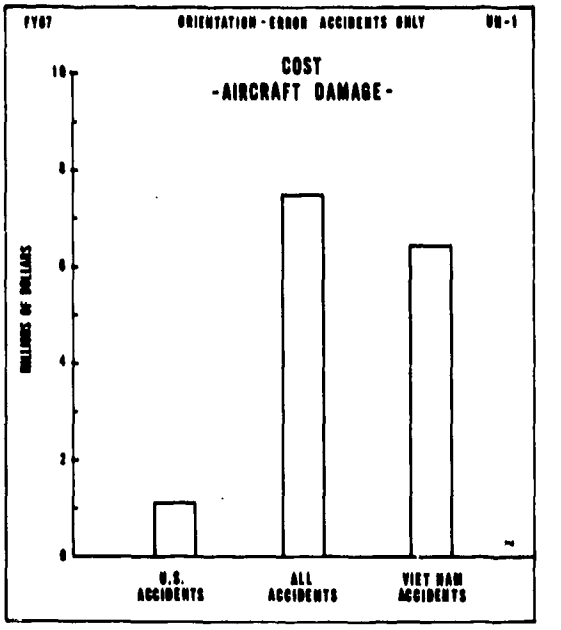
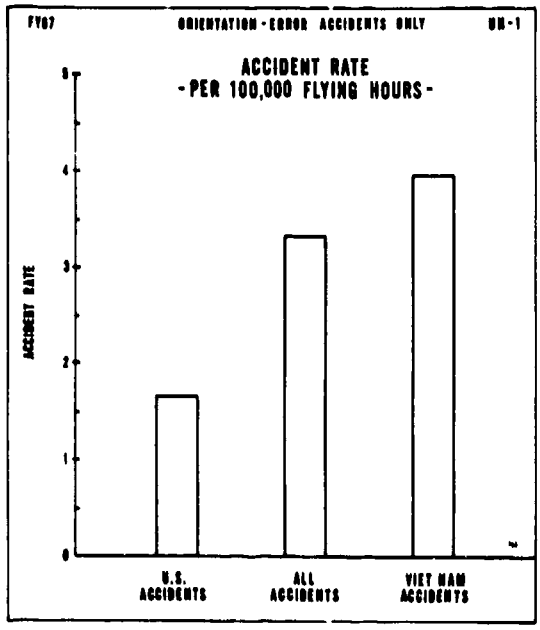


Figure 9

UH-1 Orientation-Error Accident Types: Total number of fatal accidents (A), total number of fatalities (B), total number of nonfatal injuries (C), and total dollar cost of resulting UH-1 aircraft damage (D). Note that all fatal UH-1 orientation-error accidents which were detected in the search occurred in Viet Nam.



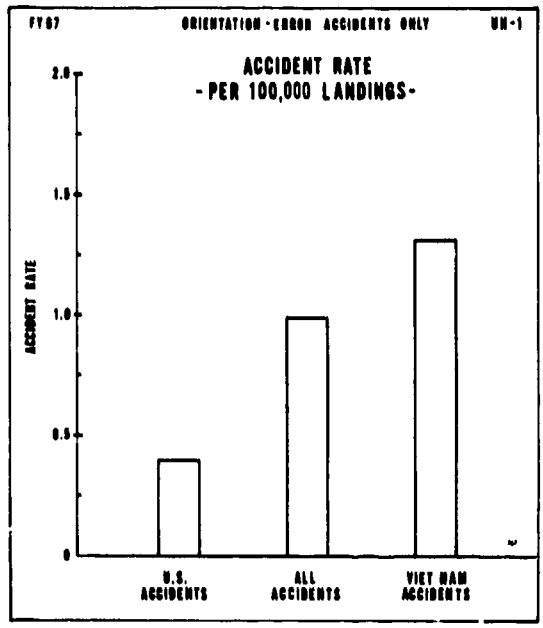


Figure 10

UH-1 Orientation-Error Accident Types: Normalized incidence data showing the average number of UH-1 orientation-error accidents per 100,000 flying hours (A) and average number of accidents per 100,000 landings (B). The total hours and total landings data of Figure 1 served as reference. These rate data are intended only as a fiscal year 1967 baseline reference for comparison with similar data for later fiscal years, which will be presented in following reports.

TABLE III
FISCAL YEAR 1967 DATA
ORIENTATION-ERROR ACCIDENTS ONLY — UH-1 AIRCRAFT

ACCIDENT INDEX	U.S. ACCIDENTS	VIET NAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	7	37	44	5.29
Minor Accidents	0	6	6	---
Total Accidents	7	43	50	6.14
Total Dollar Cost	1,103,330	6,438,847	7,542,177	5.84
Average Dollar Cost per Accident	157,619	149,741	150,844	0.95
Total Fatalities	0	38	38	---
Average Fatalities per Accident	0	0.88	0.76	---
Fatal Accidents - Number	0	15	15	---
Fatal Accidents - Percent	0.00	34.88	30.00	---
Average Fatalities per Fatal Accident	---	2.53	2.53	---
Total Injuries (Nonfatal)	11	77	88	7.00
Average Injuries per Accident	1.57	1.79	1.76	1.14

fiscal year 1967. As with both the all-accident and pilot-error accident data, the accident rate in VN due to orientation-error considerably exceeded that existing elsewhere. Based on equal flying hours, the VN rate was 2.38 times the US rate; with equal landings as reference, the VN rate was 3.31 times the US rate.

Since this report is concerned primarily with defining the magnitude of the UH-1 orientation-error problem, details pertaining to the 44 major UH-1 orientation-error accidents listed in Table III will be discussed in a separate report. The longitudinal aspect of the program will concentrate on the assimilation of data detailing the various accident factors found to be present in each case.

COMPARATIVE INCIDENCE AND COST OF UH-1 ORIENTATION-ERROR ACCIDENTS

The arrangement of the data presented in the preceding sections was selected to differentiate between the actual incidence and cost of all UH-1 accidents, pilot-error type UH-1 accidents, and orientation-error type UH-1 accidents. In this section, selected incidence and cost data are expressed in percentage figures, with the objective of gaining some insight into the relative contribution of orientation-error accidents to the over-all accident problem.

In Figure 11, the total number of fatal accidents occurring within each of the three accident classifications is expressed as the percentage of the total number of accidents occurring within the given classification. For the combined total of VN and US accidents,

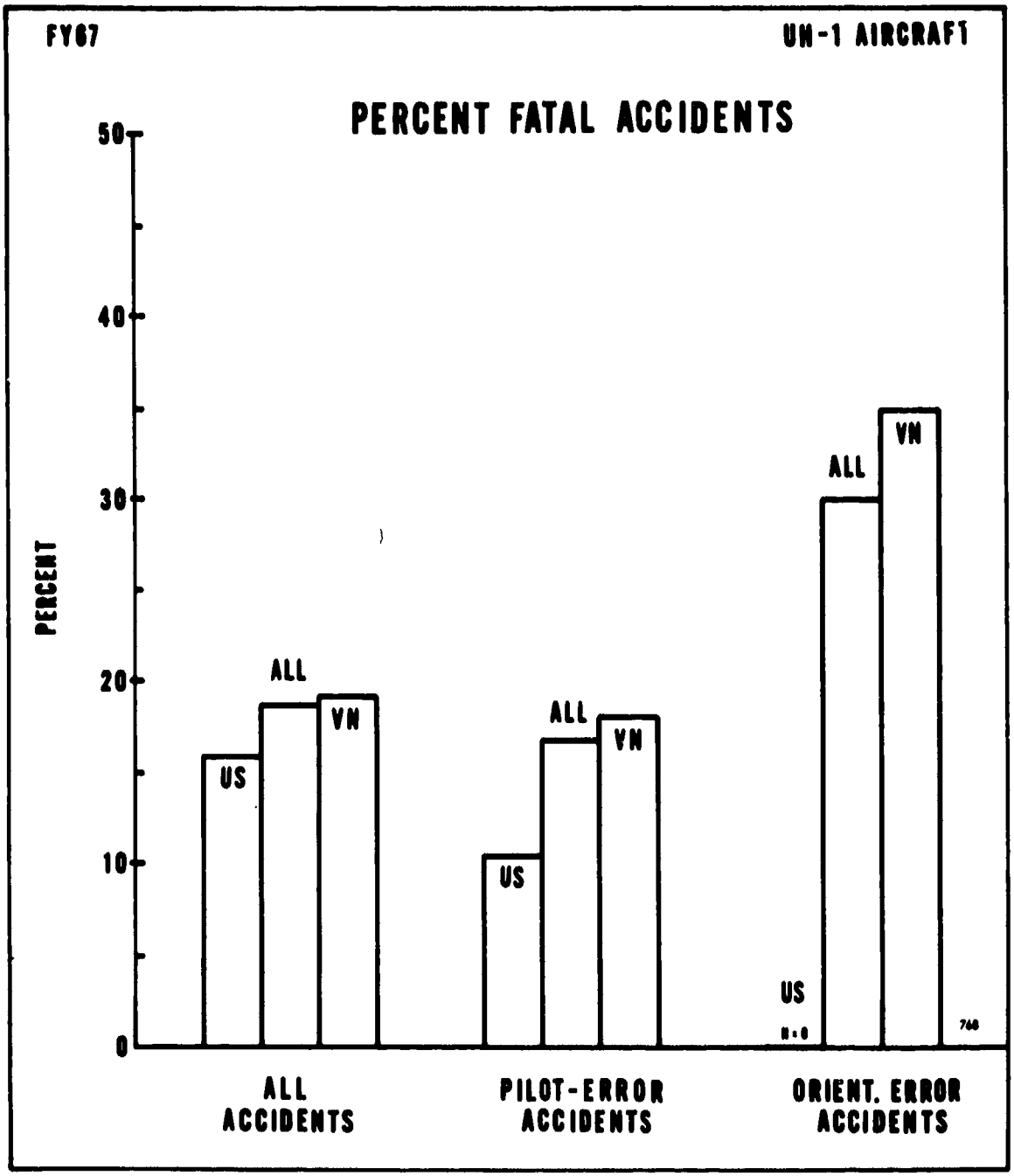


Figure 11

Comparative incidence of fatal accidents expressed as the percent of the total number of accidents within the "All Accident Type," "Pilot–Error Accident Type," and "Orientation-Error Accident Type" classifications that resulted in one or more fatalities. Note that the probability of an accident being fatal was highest for the orientation-error classification.

18.68 percent of all accidents were fatal, 16.83 percent of all pilot-error accidents were fatal, and 30.00 percent of all orientation-error accidents were fatal. The probability of a fatal accident was highest when orientation error was present. However, as indicated in Figure 12, when a fatal accident did occur, the average number of fatalities that resulted was about the same for pilot-error and orientation-error accidents, and slightly higher for all types of accidents. In terms of the average number of nonfatal injuries resulting from an accident, as indicated in Figure 13, the injury rate was greatest for orientation-error accidents and about the same for the two other accident classifications. The same trend follows for the average dollar cost of an accident as shown in Figure 14. The relative magnitude of this damage can be assessed on the basis of the replacement cost of a UH-1 which then was about $250,000.

In Figures 15 through 18, orientation-error accident statistics are expressed as their percent contribution to both the all-accident and pilot-error accident statistics. Thus in Figure 15, the total number of orientation-error accidents is expressed as the percent incidence of the total number of all accidents and percent incidence of the total number of pilot-error accidents. For fiscal year 1967, orientation-error accidents accounted for 10.99 percent of all accidents and 16.18 percent of all pilot-error accidents. Little difference existed relative to location, with the VN and US incidence being about the same. However, the reader is again cautioned to remember the low incidence of orientation-error accidents in US for that fiscal year.

As shown in Figure 16, the contribution of orientation-error fatal accidents to the over-all fatal accident problem is considerably greater than its contribution to the total accident incidence. Of the total number of fatal accidents of all types, orientation-error accidents accounted for 17.65 percent. For fatal pilot-error accidents, 28.85 percent were due to orientation error. The same trend follows for total fatalities as indicated in Figure 17. Orientation-error fatal accidents resulted in total fatalities amounting to 14.61 percent of all fatalities, and 27.74 percent of all pilot-error fatalities. In terms of the cost of orientation-error accidents, they contributed 12.04 percent of the total cost of all-accidents, and 18.62 percent of the total cost of all pilot-error accidents (Figure 18).

As with the first incidence and cost report (1), no attempt will be made to draw any further conclusions as to the over-all significance of the results. Corresponding UH-1 data are under preparation for subsequent fiscal years. The full significance of the fiscal year 1967 data depends upon whether the longitudinal analysis does or does not establish the presence of consistencies or trends in the accident experiences. Moreover, it is the function of this element of the longitudinal study only to provide quantitative UH-1 accident data; the evaluation of the data in terms of its mission implications must remain with those responsible for direction of military aviation operations.

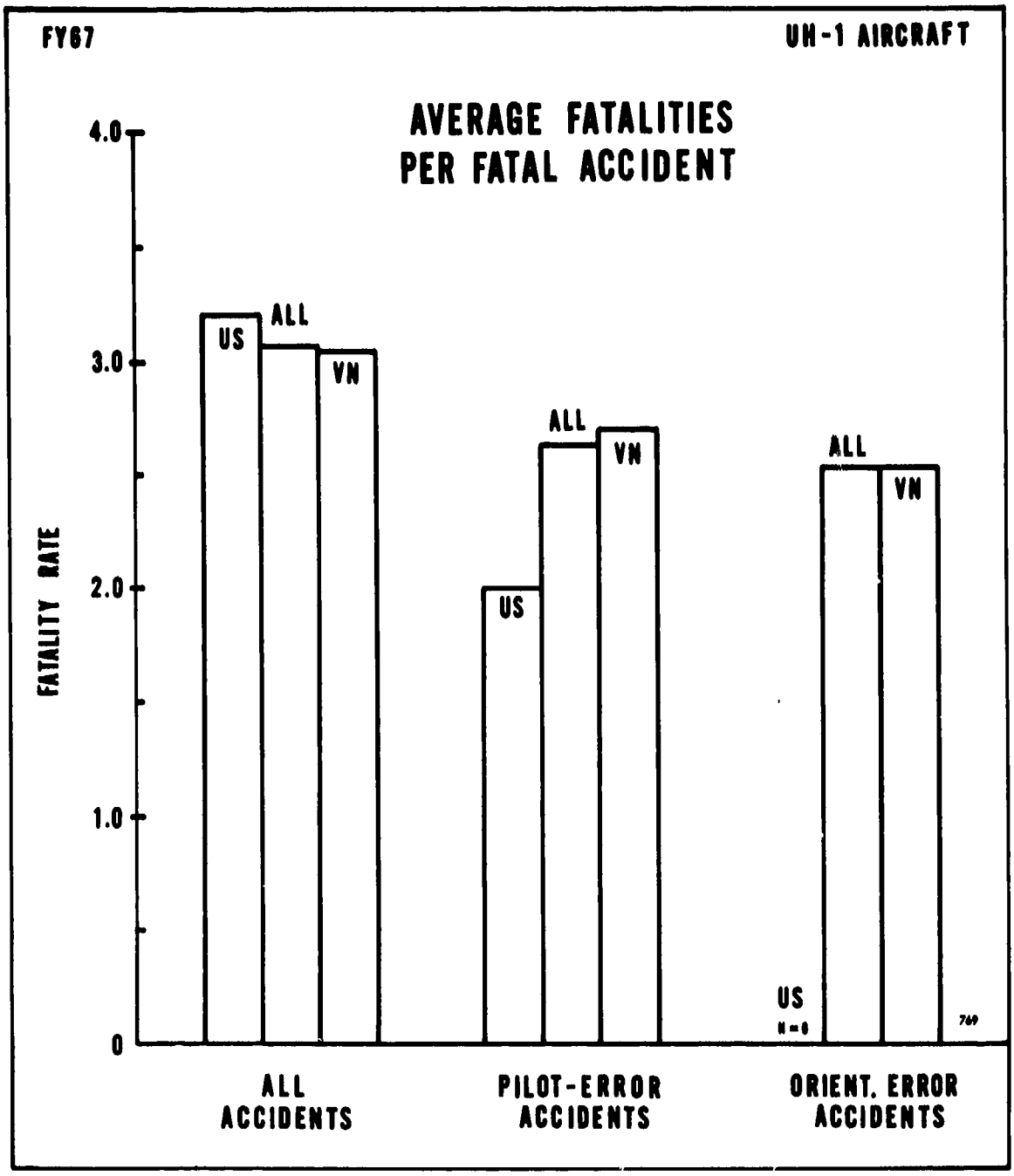


Figure 12

Average number of fatalities per fatal accident for each of the three basic accident type classifications. Note that the average was greatest for the all accident-type classification.

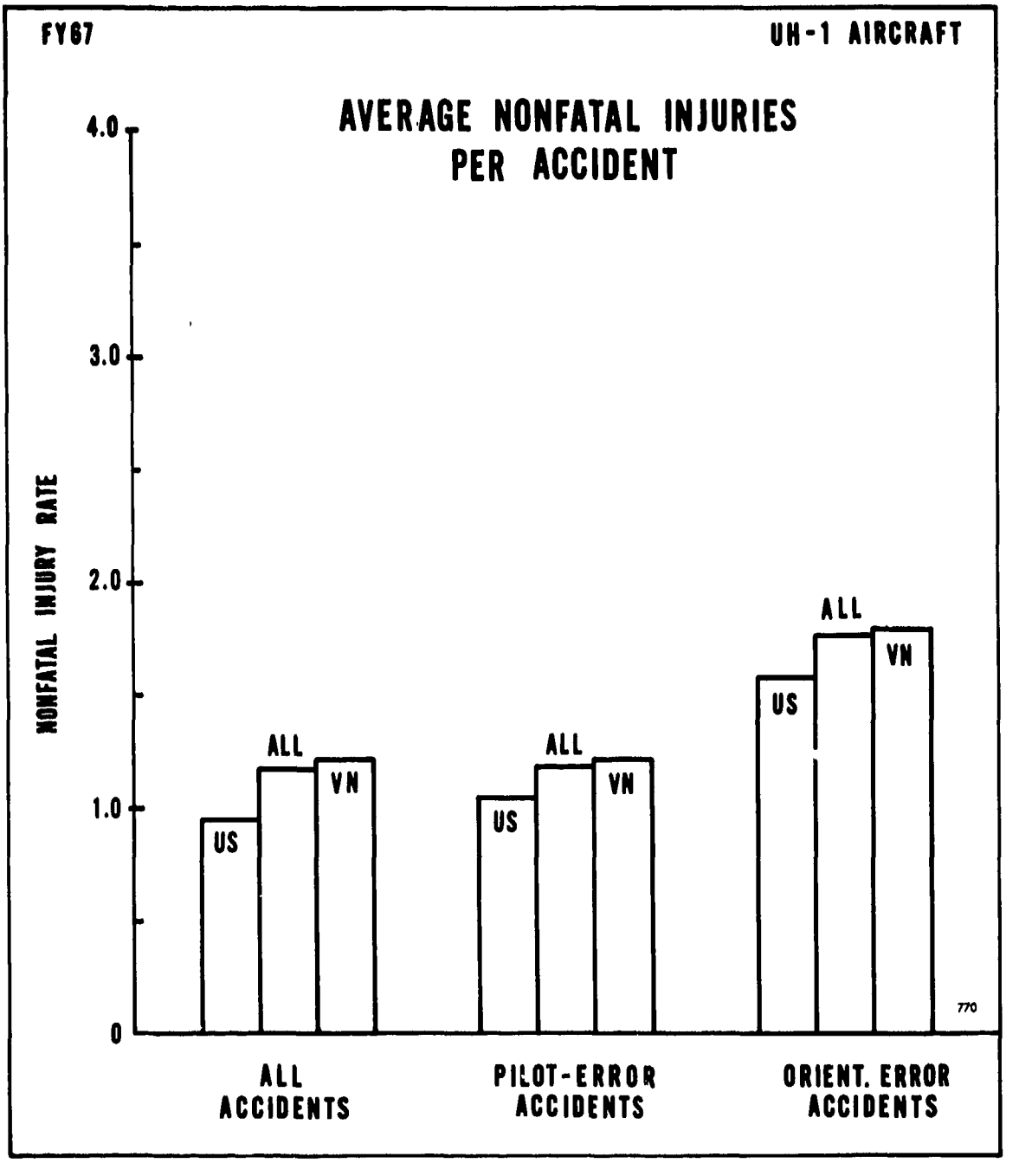


Figure 13

Average number of nonfatal injuries per accident for each of the three basic accident type classifications. The average was slightly greater for the orientation-error classification.

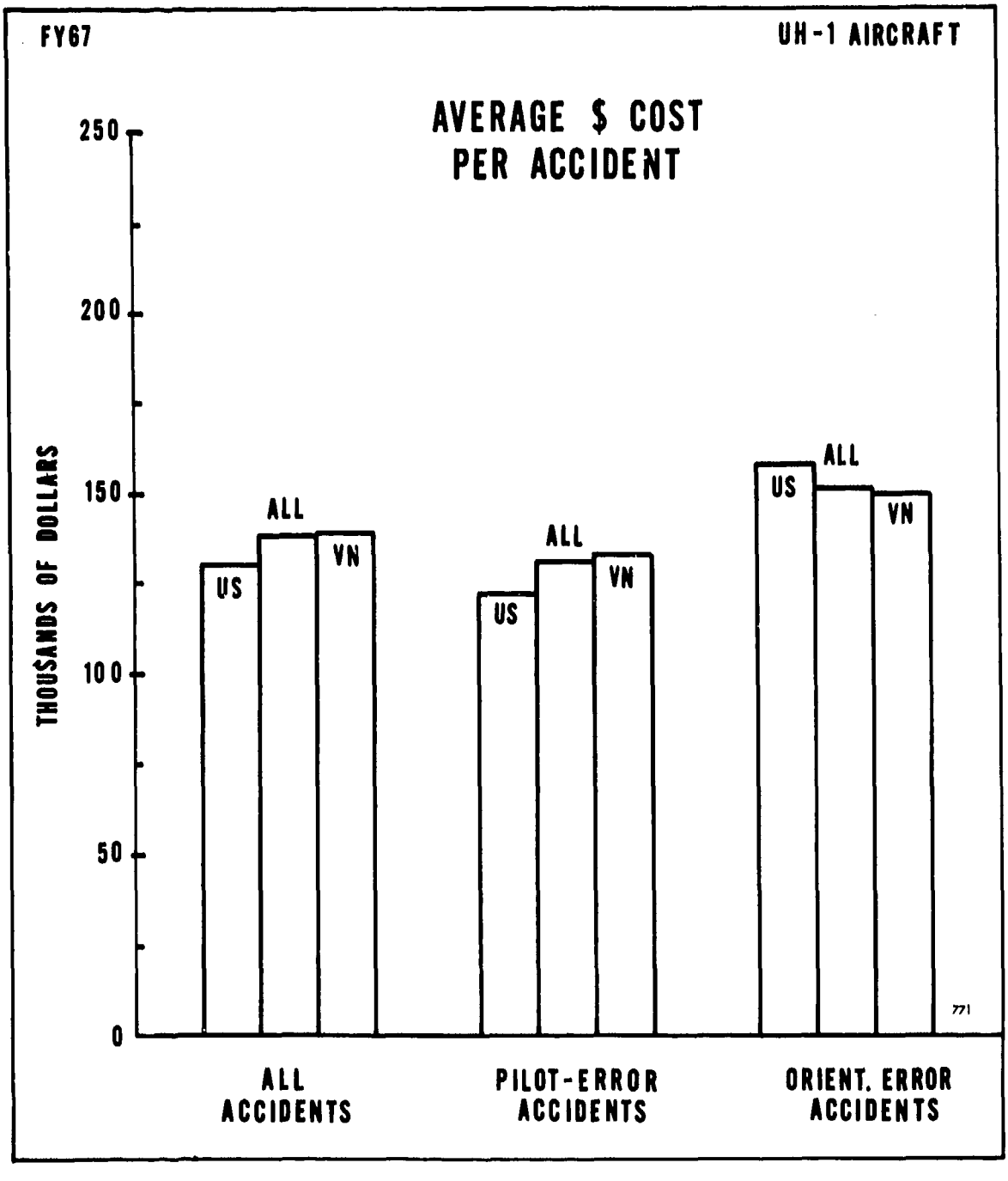


Figure 14

Average dollar cost of aircraft damage per accident for each of the three basic accident classifications. (Strike damage to a UH-1 aircraft approximates $250,000.)

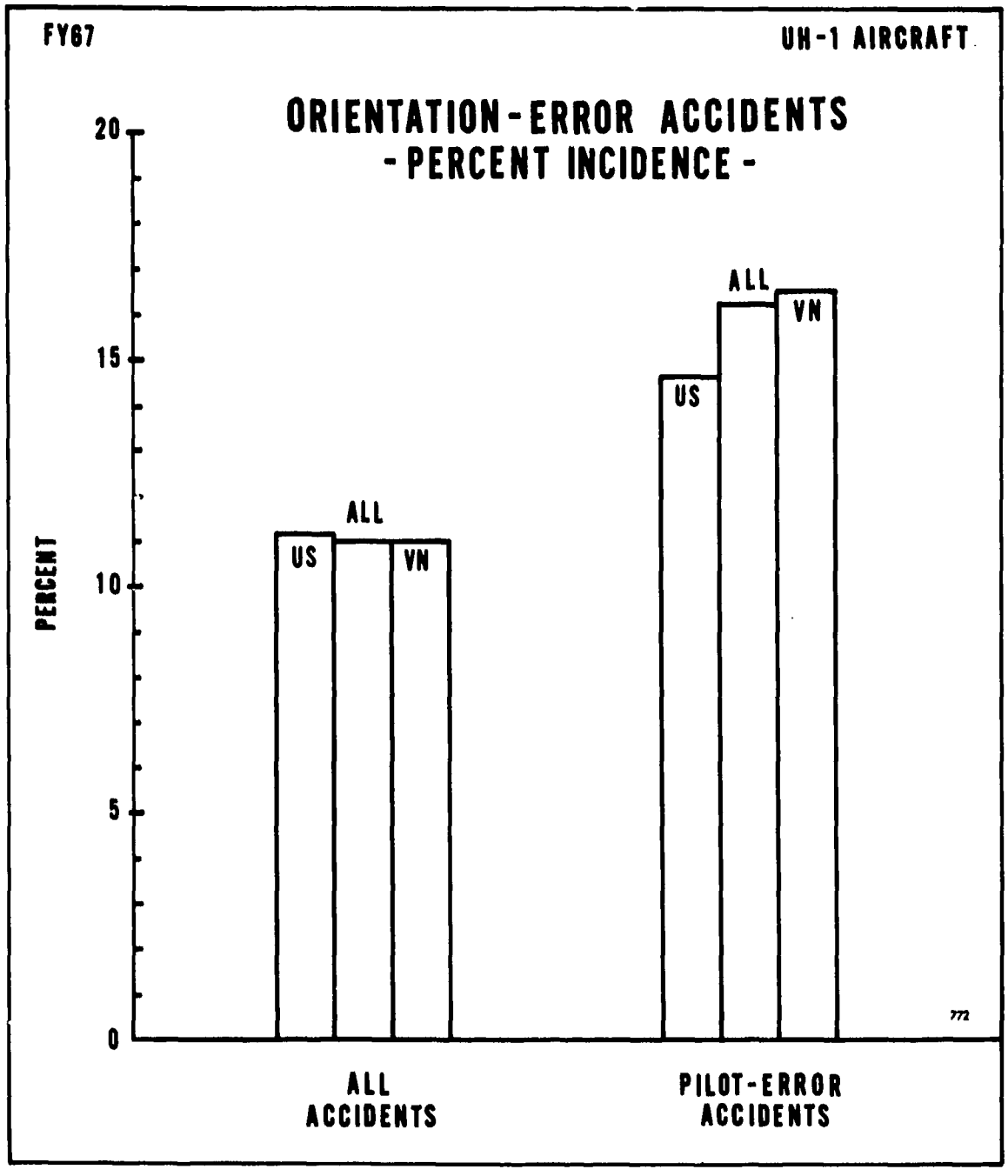


Figure 15

Percent contribution of all UH-1 orientation-error accidents to the total number of UH-1 accidents occurring within the "All Accident Type" and "Pilot-Error Accident Type" classifications.

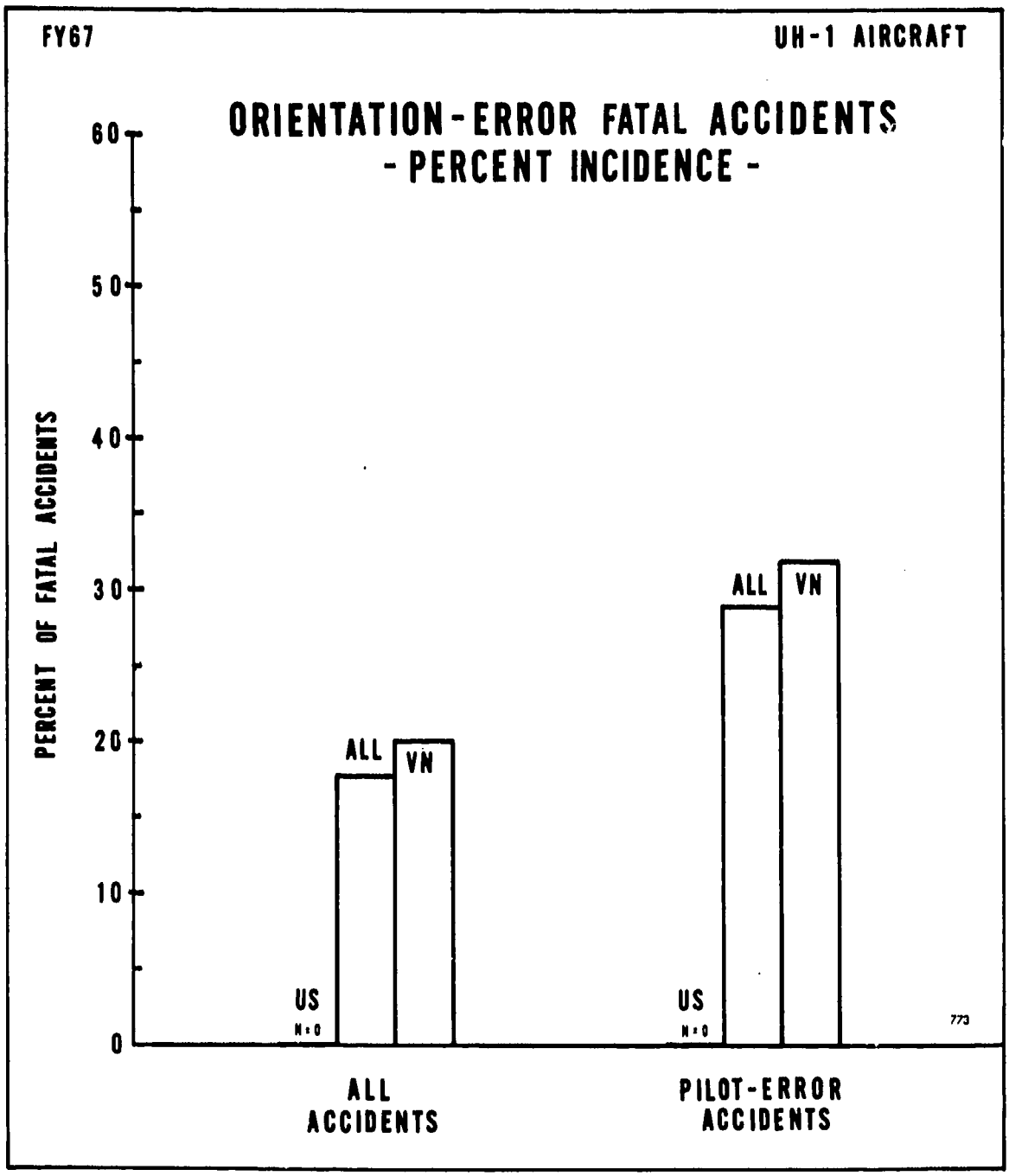


Figure 16

Percent contribution of fatal UH-1 orientation-error accidents to the total number of fatal accidents occurring within the "All Accident Type" and the "Pilot-Error Accident Type" classifications.

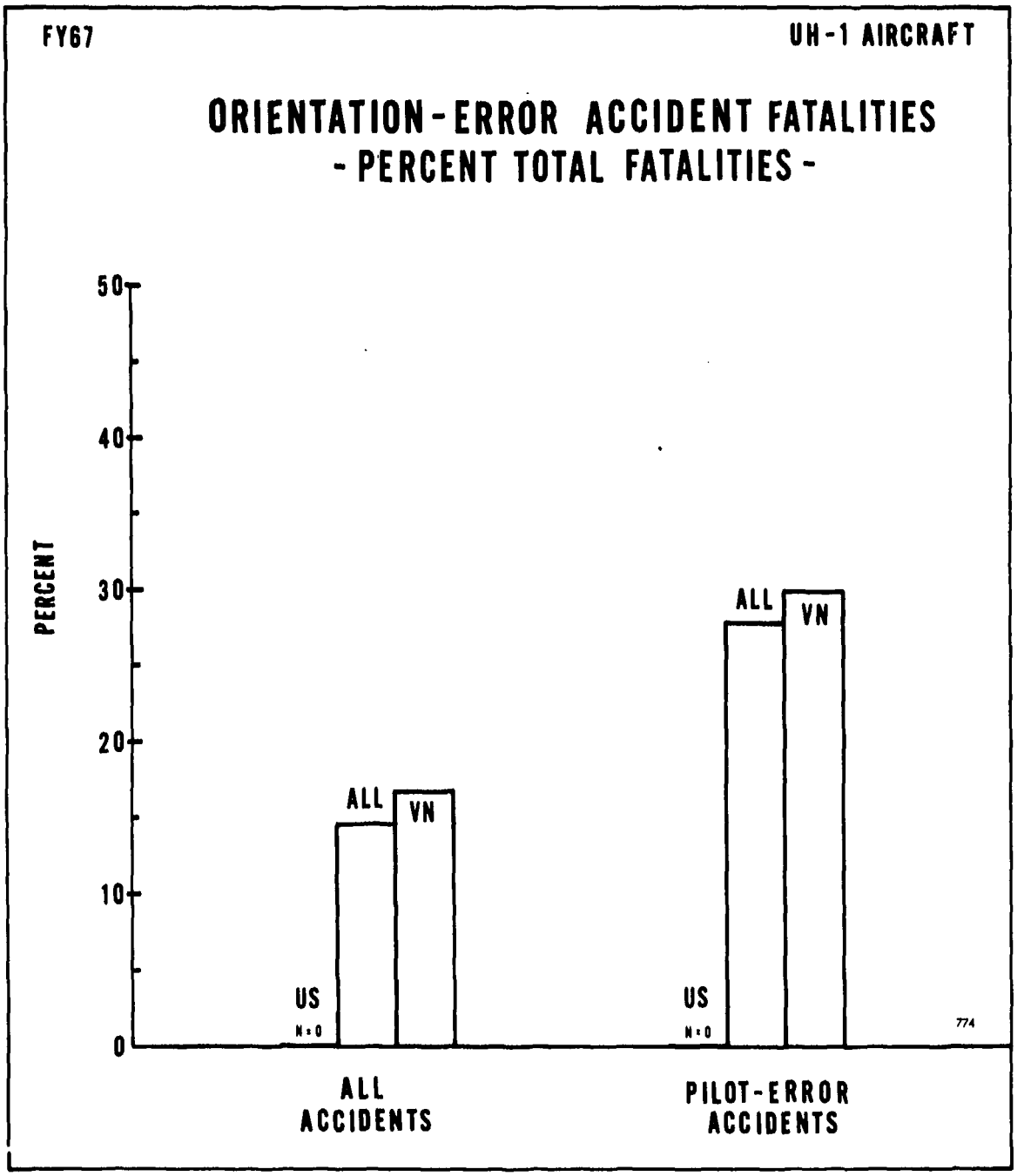


Figure 17

Percent contribution of all UH-1 orientation-error accident fatalities to the total number of fatalities occurring within the "All Accident Type" and "Pilot-Error Accident Type" classifications.

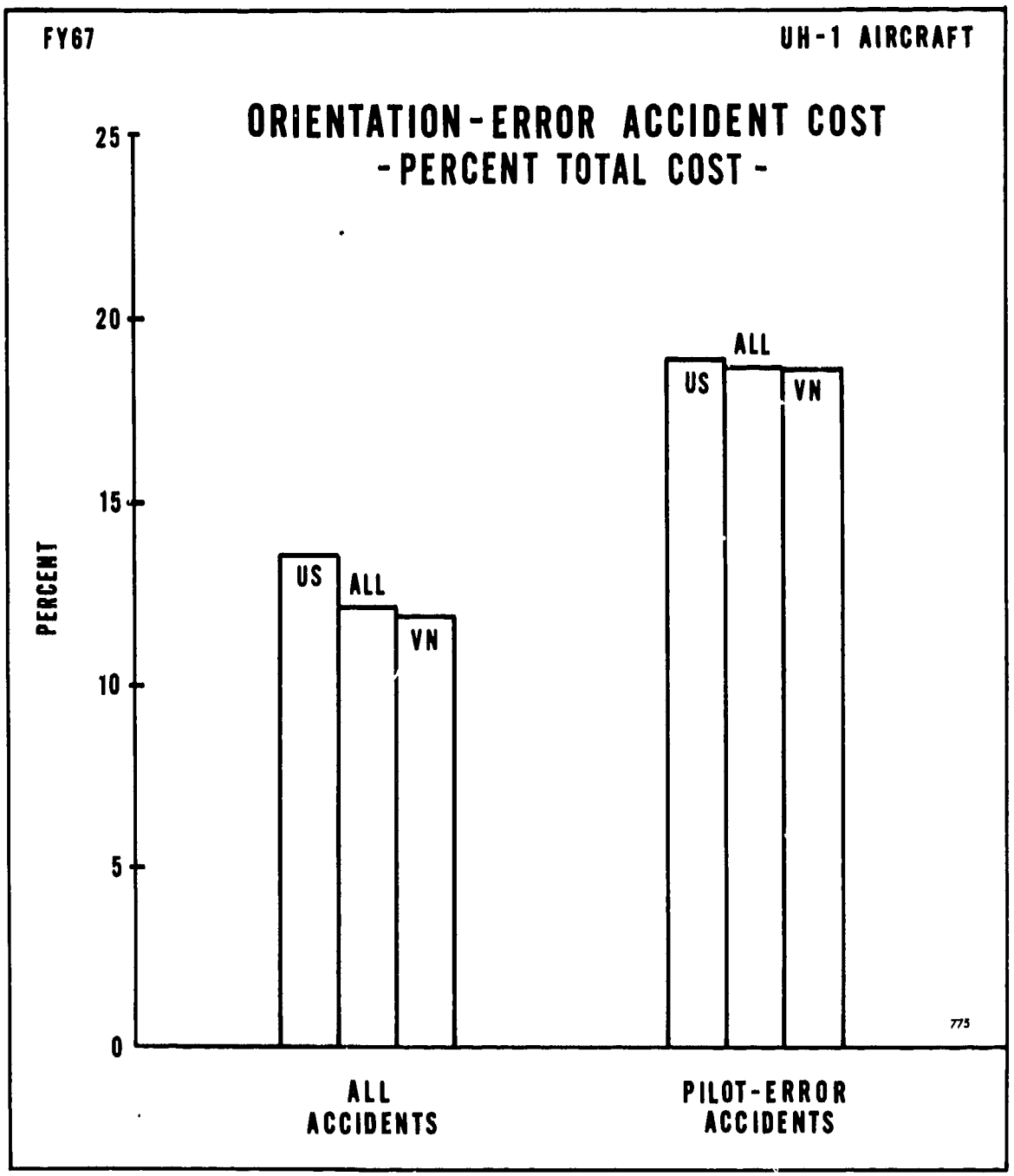


Figure 18

Percent contribution of the total dollar cost of all UH-1 orientation-error accidents to the total dollar cost of all accidents occurring within the "All Accident Type" and "Pilot-Error Accident Type" classifications.

LIST OF REFERENCES

1. Hixson, W. C., Niven, J. I., and Spezia, E., Orientation-error accidents in Regular Army aircraft during fiscal year 1967: Relative incidence and cost. NAMRL-1107 and USAARL Serial No. 70-14. Pensacola, Fla.: Naval Aerospace Medical Research Laboratory, June 1970.

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3. Department of the Army, Regulation AR 95-5: Aircraft accident prevention, investigation, and reporting. June 1966.

4. Department of the Army, Regulation AR 385-40: Accident reporting and records. December 1969.

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13. ABSTRACT

This report is the first in a longitudinal series of reports dealing with the magnitude of the pilot disorientation/vertigo accident problem in Regular Army UH-1 helicopter operations. Incidence and cost data presented for fiscal year 1967 include a total of 50 major and minor orientation-error accidents (15 of which were fatal), resulting in 38 fatalities, 88 nonfatal injuries, and a total UH-1 aircraft damage cost of $7,542,177.

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